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Seroprevalence of *Toxoplasma gondii* in Rocky Mountain Bighorn Sheep (*Ovis canadensis*)

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ABSTRACT: Serum samples from 697 Rocky Mountain bighorn sheep (*Ovis canadensis*) from North America were examined for antibodies to *Toxoplasma gondii* by the modified agglutination test incorporating mercaptoethanol and formalin-fixed tachyzoites. Antibodies to *T. gondii* were found in 25 of 697 (3.6%) sheep in titers of 1:25 (8 sheep), 1:50 (4 sheep), 1:100 (7 sheep), 1:200 (1 sheep), 1:400 (1 sheep), 1:800 (1 sheep), and 1:1,600 (3 sheep). This is the first record of *T. gondii* exposure in bighorn sheep.

Toxoplasma gondii infections have been reported from numerous domestic and wild species of animals (Dubey and Beattie, 1988). It is a major cause of abortion in goats and sheep. We are not aware of any report of *T. gondii* infection in Rocky Mountain bighorn sheep (*Ovis canadensis*), therefore the present survey was conducted to determine the level of exposure rates.

Blood samples were collected routinely when bighorn sheep were captured for herd health evaluations or translocation. Blood was collected between 1982 through 1999 in 6 western states and Canada, and sera were stored at −20 C.

Sera were initially screened at dilutions of 1:25, 1:50, and 1:500 using the modified agglutination test (MAT) as described (Dubey and Desmonts, 1987). Seropositive sera were end-titrated using 2-fold dilutions.

Antibodies to *T. gondii* were found in 25 of 697 sheep (3.6%); 20 of 411 from Washington, 1 of 24 from Idaho, 1 of 70 from Oregon, 1 of 107 from Nevada, 1 of 8 from Wyoming, 0 of 22 from Montana, 0 of 5 from Alberta, Canada, and 1 of 50 from unknown sources. The antibody titers were 1:25 (8 sheep), 1:50 (4 sheep), 1:100 (7 sheep), 1:200 (1 sheep), 1:400 (1 sheep), 1:800 (1 sheep), and 1:1,600 (3 sheep). Most positive animals (20 of 411) were from the state of Washington (Table I).

The only cluster of positive titers in the bighorn sheep samples was from a population of bighorn sheep in northeastern Washington on Hall Mountain (48°50′N, 117°15′W). Four of 14 bighorn sheep including 2 adult ewes, 1 adult ram, and 1 female lamb in this population were positive on 15 December 1998. Over 200 bighorn sheep have been captured and sampled from this population since 1982 (Foreyt et al., 1996), but other than the 4 positive samples in 1998, only 2 other sheep, including 1 adult male in 1993 and 1 adult female in 1999 were positive.

TABLE I. Prevalence of *Toxoplasma gondii* antibodies in sera of 697 bighorn sheep.

Source of bighorn sheep	No. of samples	No. of sera positive (≥1:25)
Washington	411	20
Idaho	24	1
Oregon	70	1
Montana	22	0
Nevada	107	1
Wyoming	8	1
Alberta, Canada	5	0
Unknown source	50	1

The low prevalence of *T. gondii* in bighorn sheep may be due to their habitat: they usually live in remote, mountainous regions of western North America. *Toxoplasma gondii* infection in humans and other animals is generally lower in the mountains than in the plains (Dubey and Beattie, 1988). The low prevalence of *T. gondii* antibodies in bighorn sheep is markedly different from a high prevalence of *T. gondii* in domestic sheep. With the same MAT test used in the present study, antibodies (≥1:64) to *T. gondii* were found in 65.5% of 1,564 sheep from 33 farms in the midwestern United States (Dubey and Kirkbride, 1989). The importance of *T. gondii* in bighorn sheep is unknown but should be considered in areas where the reproductive rate is less than anticipated.

The seroprevalence of *T. gondii* in bighorn sheep in the present study is markedly lower than 22% (178 of 719) seroprevalance in bighorn sheep from California reported by Clark et al. (1993) and Elliot et al. (1994); both studies used the same data. However, these authors did not mention the antibody titers found nor the serologic test used to detect *T. gondii* antibodies. Therefore, we cannot compare their results to the present study.

The authors thank O. C. H. Kwok for performing *T. gondii* serology.

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J. Parasitol., 86(3), 2000, p. 623–624

Prevalence of Antibodies to *Toxoplasma gondii* in Ostriches (*Struthio camelus*)

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ABSTRACT: Serum samples from 973 ostriches (*Struthio camelus*) in Canada were examined for antibodies to *Toxoplasma gondii* by the modified agglutination test incorporating mercaptoethanol and formalin-fixed whole tachyzoites. Twenty-eight (2.9%) of the 973 birds were found to be seropositive for antibodies to *T. gondii* at titers of 1:25 in 15 birds, 1:50 in 12 birds, and 1:500 in 1 bird. This is the first record of *T. gondii* exposure in ostriches, and it supports the hypothesis that all avian species are susceptible to *Toxoplasma* infection. Nevertheless, the results of this study suggest that the risk of acquiring toxoplasmosis from ostriches as a food source is low.

Toxoplasma gondii is known to infect many species of warm-blooded animals including birds (Dubey and Beattie, 1988; Dubey, Camargo et al., 1993; Dubey, Ruff et al., 1993a, 1993b; Dubey et al., 1994; Dubey, Goodwin et al., 1995). Ostriches (*Struthio camelus*) are large birds that have been imported into many developed countries where they are raised on game farms as nontraditional livestock. In North America, the ostrich population consists of birds that have been acquired live or as fertilized eggs from overseas sources and from locally established breeding flocks. Meat from ostriches is considered highly palatable and low in fats. Because little is known of *T. gondii* infection in wild or game-farmed ratites, we conducted the present survey for the prevalence of specific antibodies as an indication of *T. gondii* infection.

Blood samples were obtained from 973 captive-ranched ostriches in 6 Canadian provinces representing central (Quebec–36, Ontario–138) and western (Manitoba–47, Saskatchewan–48, Alberta–661, British Columbia–43) regions of the country. Birds were sampled between 4 July and 13 September 1995 and between 11 June and 15 October 1997. Overall, the serum samples represented both sexes, and age of the birds ranged from young to mature adults. Samples were originally collected by routine venipuncture of jugular, brachial, or medial metatarsal veins to accommodate testing for health certification of the birds for international export. Following these required tests, the remaining serum samples were stored at −20 C and subsequently utilized in this current study.

The samples were shipped frozen to the U.S. Department of Agriculture's Parasite Biology and Epidemiology Laboratory, Beltsville, Maryland for serologic testing. Sera were diluted 1: 25, 1:50, and 1:500 with phosphate-buffered saline and examined for *T. gondii* antibodies using the modified agglutination test (MAT) as previously described (Dubey and Desmonts, 1987). Formalin-fixed tachyzoites were used in the MAT.

Twenty-eight of 973 (2.9%) birds were seropositive for antibodies to *T. gondii* at titers of 1:25 in 15 birds, 1:50 in 12 birds, and 1:500 in 1 bird. A MAT titer of 1:25 is considered indicative of *T. gondii* infection based on statistically validated studies in pigs (Dubey, Thulliez et al., 1995; Dubey, 1997). There have been no other validation studies on serologic tests for *T. gondii* infection in animals. The MAT has been accepted as a reliable assay for *Toxoplasma* infection in several animal species including many avian species (Dubey, Camargo et al., 1993; Dubey, Ruff et al.,